INFORMATION PROCESSING, SINUS ARRHYTHMIA AND ACADEMIC ACHIEVEMENT

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THESIS

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ABSTRACT

This experiment investigated the effect of motivation on sinus arrhythmia, heart beat, and information processing rate. The two way analyses of variance which were performed showed that motivation affected sinus arrhythmia and information processing rate and did not affect heart beat. A system was developed to classify the general patterns that resulted in the measure of sinus arrhythmia as information processing levels increased. This classification system may have eventual use in predicting a student's academic achievement.

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I. INTRODUCTION

Learning institutions are concerned with an individual's mental ability, information processing rate and motivation. These factors are directly related to one's capacity to learn and his expected scholastic performance. Many colleges and universities have traditionally relied on entrance exams and I.Q. types of tests as a criterion for acceptance of a student. However, these measures have been considered by some authorities to be biased due to environmental effects and not necessarily indicative of one's inate abilities. It is interesting to consider the possibility that certain physiological functions of the body may be directly related to one's mental ability, information processing rate, and/or motivation. For example, what effect does mental ability and an increase in the information processing level have on heart beat and heart beat rate variations? If a link could be found, it would have considerable impact in universities and business alike.

Normally, there is a variance of heart beat and heart beat rate within individuals. For instance, the heart beat rate tends to increase when one inhales and decreases when one exhales. The magnitude of this rate change differs with each person, and shifts of ten to fifteen beats per minute are not uncommon. This change in heart beat rate as a function of normal breathing is known as sinus arrhythmia.

There are many other types of arrhythmia, some of which reflect undesirable abnormalities in the heart. For the purpose of this paper, however, only sinus arrhythmia in normal, youthful hearts will be considered.

This experiment extends the work of Kalsbeek (1968) and Bonsper (1970). Kalsbeek examined the effect of increasing the number of binary choices per minute on sinus arrhythmia and Bonsper investigated the effect of increasing the amount of information to be processed. This experiment will survey the effect of increasing the amount of information to be processed on sinus arrhythmia in motivated and unmotivated groups. Also sinus arrhythmia changes will be correlated with past academic performance.

This experiment used four different levels of the amount of information to be processed. The first level was the resting state in which no information was presented. The remaining levels required processing one, two and three bits respectively. The one bit conforms to information theory (Bell, 1953), i.e., the choice between two equally likely alternatives. The two and three bit decisions were determined by taking log to the base 2 of the number of equally likely alternatives (Poock, 1967).

The measure of sinus arrhythmia was consistent with that of Bonsper. The number of R waves was counted during a specific time interval and the mean heart beat was drawn on the electrocardiogram rate curve. The area on either side of this line was the sinus arrhythmia. This method

differed from Kalsbeek who determined irregularity by counting the frequency the electrocardiogram rate differed from the mean rate by specified values.

In addition, a new method for classification of individuals based on the changes of their sinus arrhythmia as a function of the amount of information being processed has been developed. This classification takes into consideration the fact that while no two subjects will respond in an exact manner, certain patterns are prevalent. Individuals with similar patterns will be grouped for comparison purposes.

II. METHOD

A. APPARATUS

A Beckman type RM Dynograph Recorder was used to monitor the electrocardiogram rate and heart beat. Both the electrocardiogram rate and heart beat were recorded simultaneously on Recording Charts Graph Paper. A cardiotachometer coupler was utilized to calculate the electrocardiogram rate. The time increment between successive R waves was measured by the cardiotachmeter and instantaneous heart beat rate was then calculated. A continuous plot of this rate was recorded on the graph paper. The recorder was calibrated so that there was 30 millimeters between the 60 and 120 beats per minute with a chart speed of five millimeters per second. Three Beckman electrodes were positioned on the subjects (Ss) chest in order to obtain the readings.

A visual test similar to that of Poock (1967) was used to present the one, two and three bit information levels. Numbers were lighted for presentation on a 3" by 4" transilluminated screen. The Ss responded to the numbers by pushing colored buttons that corresponded to the number presented. These buttons were located on a panel directly below the screen. The numbers 3 and 4 were used as the equally likely alternatives for the one bit decision; 3, 4, 5, and 6 were used for the two bit decision; and 1 through 8 were used for the three bit decision. A probability

randomizer was employed in order to display the numbers in a completely random manner. This was accomplished by programming a random sequence of numbers into the machine and by designating a probability of .55 that the number would appear during its turn in the program sequence. The base rate at which choices were possible was one per second, however, this varied slightly depending on whether the number appeared. Ss used the index finger of each hand to press the buttons for all three information levels of the experiment. Also, the cumulative time between when the signal appeared and when the subject responded was maintained to the nearest one hundredth of a second. The Ss wore earphones connected to a white noise generator in order to mask background noises.

B. TEST SITE AND SUBJECTS

The experiment was conducted in the Human Engineering and Man-Machine Systems Laboratory of Naval Postgraduate School. Ss were seated in a chair facing the transilluminated screen and the response panel. The experimenter (E) stood in front of the RM Dynograph Recorder which was adjacent to the screen and response panel.

There were a total of 57 subjects that were all male officer students at the Naval Postgraduate School. Of the 57 Ss there was a total of 31 Navy, 18 Army, 1 USMC, and 7 Foreign. The ages of the Ss ranged between 25 and 36 years, with the mean 29 years old.

C. PROCEDURE

The Ss were first given a questionnaire to complete in order to obtain background data. After completing this form, the Ss stripped to the waist and the E affixed the electrodes on the Ss chest. The S was then seated and given instructions concerning the experiment. The first 30 Ss were considered the unmotivated group. It was explained the experiment would consist of four parts. Part one was a five minute rest period which would allow the S's heart to reach a steady state rest condition. Parts two, three and four involved a two minute presentation of the one, two, and three bit tasks, with a one and one half minute rest period between tasks. The position of the numerals on the trans-illuminated screen was shown to the Ss along with the one to one correspondence between the buttons on the response panel and the numerals. The Ss were directed to use only the index finger of each hand and to respond to each lighted number as rapidly as possible. Earphones connected to a white noise generator were given to the Ss for adjustment. The E subsequently regulated the dynograph while the Ss were resting in order to obtain an accurate electrocardiograph. The E gave the Ss a 10 second warning prior to the beginning of parts two, three and four. Also, the actual number of decisions made in each part and corresponding cumulative response time were recorded by E. At the conclusion of the experiment the E discussed the purpose and objectives of the experiment.

The remaining 27 Ss were designated the motivated group. This portion of the experiment was conducted in an identical manner as for the unmotivated group. In addition, there were monetary rewards offered to this group for exceptionally rapid response time. Ten dollars was the reward for the fastest reaction time; five dollars and three dollars were for the second and third fastest reaction times.

D. REDUCTION OF DATA

At the conclusion of experimentation the following data had been obtained; 57 electrocardiogram rate traces, 57 response times for the one, two and three bit levels, and the number of decisions made by each S at the different information levels. In addition, information concerning undergraduate scholastic performance and graduate scholastic performance to date was obtained from the Registrar, Naval Postgraduate School for 56 of the 57 Ss.

The mean heart beat rate for each of the four parts was computed by counting the number of R waves during the last minute of the rest period and the final minute of each of the information presentation parts. These particular minutes were selected for analysis because it was felt they were representative of the steady state heart beat and heart beat rate for the four parts of the experiment. In other words, the Ss heart had sufficient time to reach the pattern that reflected the effect of information processing.

The mean heart beat rate was used as the base line for computation of the sinus arrhythmia. The measure of sinus arrhythmia was calculated in the manner outlined by Bonsper (1970) (see Figure 1) with the exception that each square millimeter of area between the base line and heart beat rate was summed to obtain a numerical estimate of the sinus arrhythmia. Periods for measurement of sinus arrhythmia corresponded to the measured heart beat periods.

Next, the information processing rate for each of the Ss was computed. The average time to process each decision was obtained by dividing the cumulative reaction time by the number of decisions. For example, if it took 35 seconds to perform 70 one bit decisions, the rate was two decisions per second. A regression was then performed in order to obtain the slope of the line through the points which were plotted with the average reaction time as the ordinate and number of information bits as the abscissa. The slope of the line was regarded as an individual's overall information processing rate.

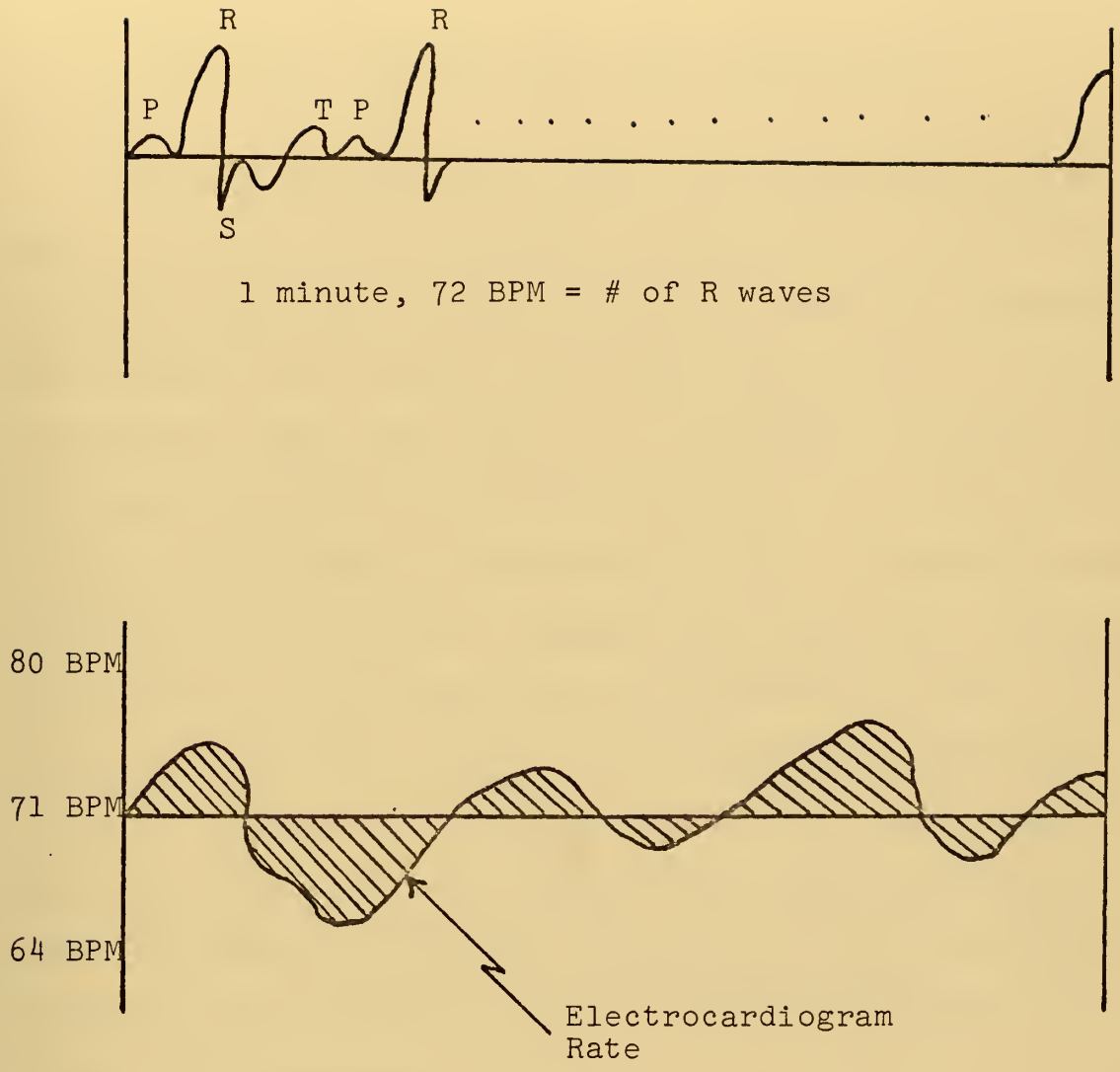

Figure 1. Shaded Area Represents Measure of Sinus Arrhythmia.

III. STATISTICAL TESTS AND RESULTS

A variety of statistical tests was performed on the data. The first test was a two way analysis of variance (ANOVA) design which compared the sinus arrhythmia measurement between the motivated and unmotivated groups in each information level (see Table I). The results indicated that there was a difference between groups at $p = .05$ and a difference in information levels at $p = .001$. A Duncan Multiple Range Test (see Table II) compared the mean sinus arrhythmia measurement of the groups and the information levels. The motivated group had a higher sinus arrhythmia measurement at $p = .05$ as expected from the analysis of variance results. The rest measurement was statistically different from the other information processing levels at $p = .001$ and there was no difference between the sinus arrhythmia measures for 1, 2 and 3 bit processing levels.

A two way ANOVA (see Table III) was also used to compare heart beat between groups and between information levels. The results were not statistically significant. However, mean heart beat was higher in the motivated group than the unmotivated group. Heart beat was almost identical within each group for the one, two and three bit tasks and represented an average increase of five beats per minute over the rest level.

TABLE I

ANALYSIS OF VARIANCE ON SINUS ARRHYTHMIA
FOR MOTIVATED AND UNMOTIVATED GROUPS

Source	df	Ss	F	p
Between Groups	1	38801.20	4.37	.05
Between Information Processing Levels	3	776850.79	29.2	.001
Interaction Between Groups and Information Processing Levels	3	47753.06	1.80	.25
Error	208	1840553.00		
TOTAL	215	2703958.05		

TABLE II

RESULTS OF DUNCAN MULTIPLE RANGE
TEST ON SINUS ARRHYTHMIA

Group	Rest	1 Bit	2 Bit	3 Bit	Mean
Motivated	356.0	191.1	182.0	179.44	227.1
Unmotivated	278.0	185.9	174.1	163.2	200.3
Composit	314.2	191.7	177.6	171.4	213.7

The mean of motivated and unmotivated groups are statistically different at p = .05.

The rest measurement was statistically different from the 1, 2, and 3 Bit means at p = .001.

TABLE III

ANALYSIS OF VARIANCE ON HEART BEAT FOR MOTIVATED AND UNMOTIVATED GROUPS

Source	df	Ss	F	p
Between Groups	1	332.52	1.95	.25
Between Information Processing Levels	3	960.26	1.87	.25
Interaction Between Groups and Information Processing Levels	3	8.49	.093	ns
Error	208	35729.68		
TOTAL	215	37030.95		

Likewise, a two way ANOVA (see Table IV) was used to compare the information processing rate at the one, two, and three bit levels between motivated and unmotivated groups. The results indicated there was a difference between groups at $p = .05$ and between information processing levels at $p = .001$. A Duncan Multiple Range Test (see Table V) confirmed that the mean information processing rate was higher in the motivated group than in the unmotivated group at $p = .05$.

A linear correlation analysis was performed between Ss' previous undergraduate scholastic performance and the following: mean sinus arrhythmia, mean heart beat, information processing rate, difference between sinus arrhythmia measured during rest and that measured during the three bit

information level, and the percent difference observed between the rest and three bit levels. A correlation analysis was also performed between the Ss' current scholastic performance at the Naval Postgraduate School and the above factors. Additionally, for those students that had taken the Graduate Records Exam (GRE) Aptitude Test, the correlation was checked between the GRE quantitative score and the above factors (see Table VI). None of the correlations showed a strong statistical link.

Figure 2 shows the results of the experiment in graphical form.

TABLE IV

ANALYSIS OF VARIANCE ON INFORMATION PROCESSING RATE FOR MOTIVATED AND UNMOTIVATED GROUPS

Source	df	Ss	F	p
Between Groups	1	.67	4.71	.05
Between Information Processing Levels	2	160.66	561.	.001
Interaction Between Groups and Information Processing Levels	2	.04	.15	ns
Error	156	22.32		
TOTAL	161	183.69		

TABLE V

RESULTS OF DUNCAN MULTIPLE RANGE TEST ON INFORMATION PROCESSING

Group	1 Bit	2 Bit	3 Bit	Processing Mean
Motivated	1.84	3.31	3.29	3.15
Unmotivated	1.75	3.15	4.15	3.02
Composit	1.79	3.24	4.22	3.08

The mean results for the groups were statistically different at p = .05.

The 1, 2, and 3 Bit levels were statistically different from each other at p = .001.

TABLE VI

RESULTS OF LINEAR CORRELATION

Dependent Variable	Independent Variable	Linear Correlation Coefficient (N)	p
Undergraduate QPR*	Mean Arrhythmia	-.203	.25
Undergraduate QPR*	Information Processing Rate	-.081	NS
Undergraduate QPR*	Arrhythmia Difference Between Rest and Three Bit Level	-.222	.25
Undergraduate QPR*	Three Bit Level Arrhythmia % of Rest Arrhythmia	.121	NS
NPS QPR**	Mean Arrhythmia	.046	NS
NPS QPR**	Information Processing Rate	.175	.25
NPS QPR**	Arrhythmia Difference Between Rest and Three Bit Level	-.083	NS
NPS QPR**	Three Bit Level Arrhythmia % of Rest Arrhythmia	.010	NS
GRE Qualitative Score ***	Mean Arrhythmia	.032	NS
GRE Qualitative Score***	Information Processing Rate	.097	NS
GRE Qualitative Score***	Arrhythmia Difference Between Rest and Three Bit Level	.004	NS
GRE Qualitative Score***	Three Bit Level Arrhythmia % of Rest Arrhythmia	-.190	NS
GRE Qualitative Score***	NPS QPR	.247	NS

*Sample Size 55
**Sample Size 56
***Sample Size 17

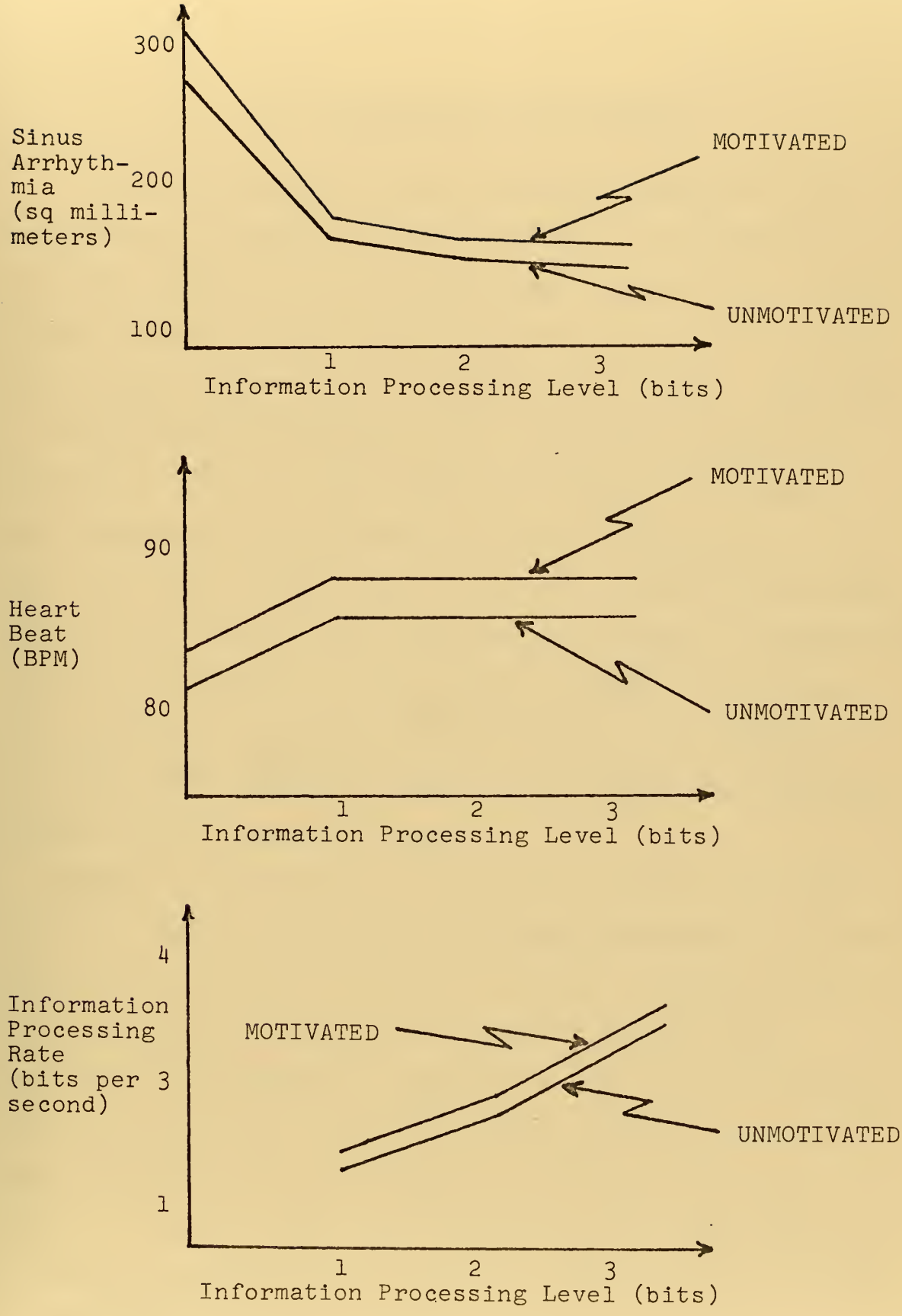
300
200
100
Sinus Arrhyth-mia (sq milli-meters)
MOTIVATED
UNMOTIVATED
1
2
3
Information Processing Level (bits)
90
80
Heart Beat (BPM)
MOTIVATED
UNMOTIVATED
1
2
3
Information Processing Level (bits)
4
1
Information Processing Rate (bits per 3 second)
MOTIVATED
UNMOTIVATED
1
2
3
Information Processing Level (bits)

Figure 2.

IV. CLASSIFICATION OF SUBJECTS

Due to the results of the correlation analysis, the measurement of each Ss' sinus arrhythmia was carefully reviewed. While it was apparent that no two Ss were alike, there did exist similar patterns which the sinus arrhythmia measurement followed for the majority of the Ss. Therefore, a classification system for sinus arrhythmia patterns was developed. The patterns depicted in Figures 3 through 8 are considered to be representative of the majority of the Ss. Note that in each case the sinus arrhythmia measurement for the rest part of the experiment was greater in magnitude than the measurements taken during information processing. The remainder of the subjects (14.2%) were not considered to demonstrate a specific pattern, but rather the measured response was a random phenomena.

Group 1 (see Figure 3) experienced a sharp drop (usually around 60%) in their sinus arrhythmia measurement in going from the rest level to the one bit level. However, subsequent information levels did not affect further sinus arrhythmia measurements. Apparently, these Ss had reached their base level at the one bit task and there was limited spare mental capacity available for the more difficult levels. Groups 2 and 3 (see Figures 4 and 5) responded in a manner similar to group 1 with the exception they dropped to their base level on the two and three bit levels

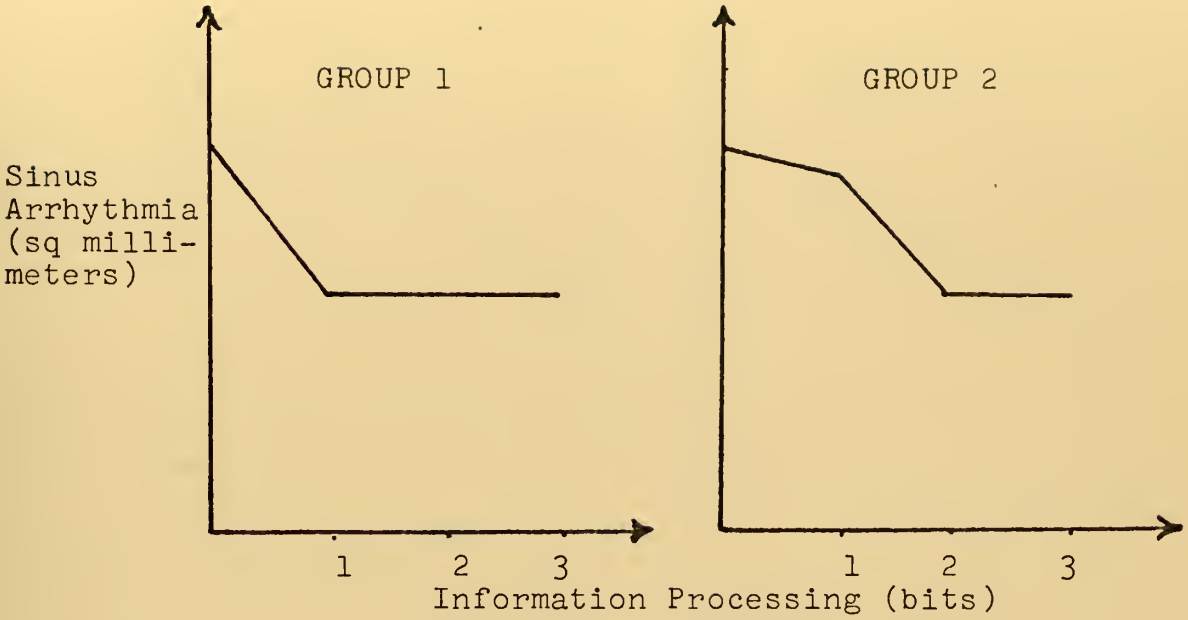

Figure 3.

Figure 4.

respectively. Group 4 responded to each information level in a uniform incremental manner (see Figure 6). Apparently, these Ss allocated mental capacity in proportion to the difficulty of the task. Group 5 responded in an incremental manner in the one and two bit tasks and then demonstrated a sharp increase in sinus arrhythmia measurement for the three bit level (see Figure 7). Apparently, these Ss became bored with the experiment in the final phase and ceased to apply themselves. Group 6 underwent a sharp drop in sinus arrhythmia in going from the rest level to the one bit level and then exhibited higher measurements for the two and three bit levels (see Figure 8). A possible explanation is that these Ss reached their base level for the one bit task by rigorously applying themselves and, as the

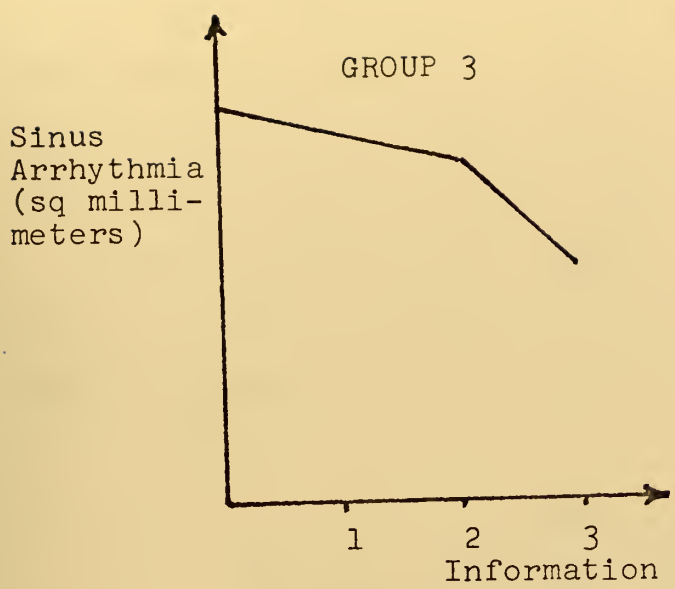

Figure 5.

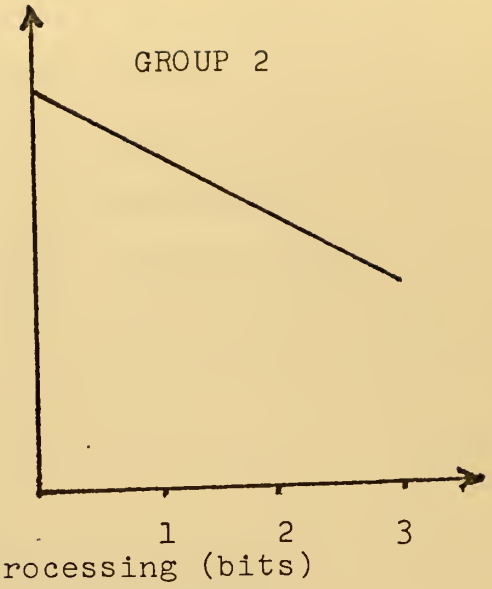

Figure 6.

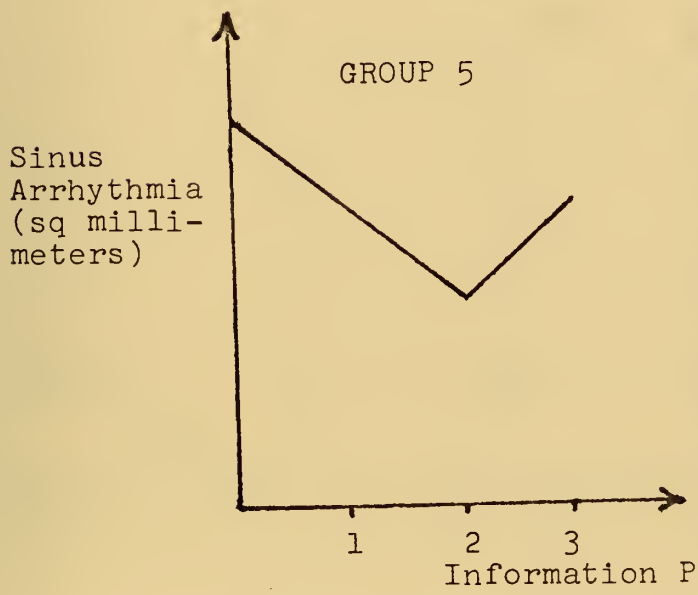

Figure 7.

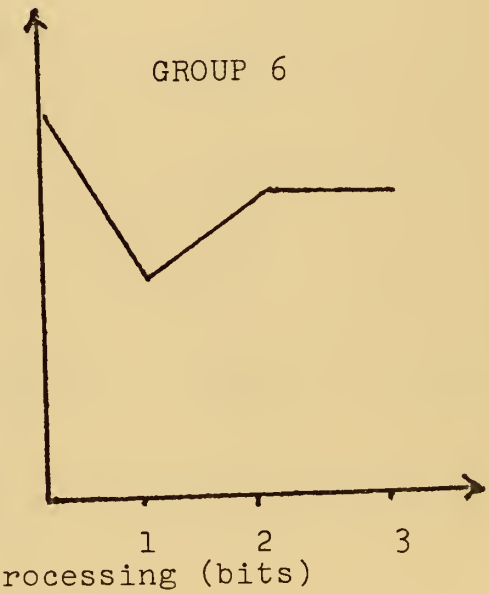

Figure 8.

experiment progressed, they allocated mental capacity as necessary or became bored. The author recognizes that the above classification scheme is a rough approximation which will only be validated with further experimentation.

Table VII depicts the relative size of the various groups as well as information concerning the quality point rating by group.

TABLE VII

COMPARISON OF SINUS ARRHYTHMIA PATTERN GROUPS NPS SCHOLASTIC PERFORMANCE

Group	# of Ss	# of Total	High QPR	Low QPR	Ave. QPR
1	8	14.2	2.0	-.53	1.39
2	7	12.5	2.88	1.88	2.13
3	7	12.5	2.35	1.35	1.75
4	6	10.8	3.0	1.35	2.42
5	10	17.9	2.76	1.0	2.01
6	10	17.9	3.0	1.0	2.22
No Pattern	8	14.2	2.88	1.12	2.18
TOTAL	56*	100	3.0	-.59	1.99

*Scholastic data not available on 1 S.

V. DISCUSSION

The results of this experiment were consistent with results obtained by Bonsper and Kalsbeek, i.e., that sinus arrhythmia decreased as information processing increased, and that heart beat was not significantly affected by information processing.

It was found that the motivated group had a lower sinus arrhythmia measurement at each level of the experiment. Also the motivated group's information processing rate and heart beat were slightly higher than the unmotivated groups at each level. A partial explanation for this observation may be that the motivated group was probably trying harder.

Two of the patterns observed were of particular interest; pattern numbers 1 and 4. The sinus arrhythmia measurement taken for the one bit task for Ss in group number 1 was reduced significantly from the rest measurement. Additional information tasks did not, however, cause any subsequent shifts. This group also had the lowest quality point rating. Perhaps this group was mentally taxed by the one bit presentation and did not have a reserve capacity to respond to a higher number of bits. The Ss in group 4 responded in a uniform incremental fashion to the information presentation. That is, each sinus arrhythmia measurement decreased as information levels increased. The average quality point rating for this group was the highest of

all groups and over one point higher than the average for group 1. An explanation for this group's higher performance may be that they responded with mental effort in proportion to the difficulty of the task presented. (It should also be pointed out that the student's current grade point used was that after two quarters study in an eight quarter program. A better validation of these patterns and higher correlations will be investigated when the student's grade points for their full masters program are available.)

At present there do not exist any formulas, models or tests that can with certainty predict a student's or employee's performance. It appears from this experiment there is a link between sinus arrhythmia patterns and student quality point rating. A larger sample size and extended studies may refine this relationship. Ultimately, sinus arrhythmia may provide a physiological measure that will compliment other measures and enhance selection processes in academic and business establishments.

APPENDIX A

SUMMARY OF OBSERVED DATA FOR MOTIVATED GROUP

Subject	Sinus Arrhythmia				Heart Beat			
	Rest	1 Bit	2 Bit	3 Bit	Rest	1 Bit	2 Bit	3 Bit
1	362	126	132	207	100	107	98	90
2	160	135	167	190	107	107	99	99
3	541	197	133	166	93	96	102	97
4	456	106	138	155	92	89	87	87
5	557	373	395	291	71	71	78	84
6	674	244	327	429	88	97	98	90
7	351	210	245	192	70	73	76	74
8	319	202	175	152	83	89	88	86
9	395	184	118	125	112	119	120	120
10	330	223	144	143	66	72	67	68
11	285	127	169	117	88	72	75	73
12	111	66	67	96	84	88	91	89
13	233	113	238	130	63	73	73	73
14	426	205	177	126	86	76	80	75
15	297	206	326	196	81	82	85	88
16	348	216	137	157	83	80	90	86
17	372	297	287	272	83	89	88	87
18	267	115	203	167	69	94	104	104
19	350	154	94	133	98	105	113	112
20	215	91	112	104	90	96	99	97
21	370	211	147	213	78	81	88	87
22	655	329	153	128	88	96	100	108
23	480	274	217	391	75	70	76	75
24	255	316	147	168	84	92	90	86
25	378	206	229	223	82	90	84	82
26	197	130	123	89	75	96	88	84
27	228	105	114	85	75	79	82	80

Subject	Information Processing Rate			Scholastic QPR		SA Group
	1 Bit	2 Bit	3 Bit	Undergrad	NPS	
1	1.96	3.74	3.99	2.57	1.41	5
2	1.76	3.49	3.99	1.55	2.41	NC
3	1.93	3.32	4.21	2.55	2.76	5
4	1.46	3.47	3.85	1.38	1.71	6
5	1.93	3.34	4.14	2.02	1.35	3
6	1.53	3.36	4.71	2.09	2.12	6
7	2.00	4.27	4.19	1.64	3.00	6
8	1.55	2.88	4.19	1.66	3.00	4
9	1.90	3.17	3.86	1.61	1.88	2
10	1.92	3.30	5.16	2.18	2.88	2
11	1.88	3.58	4.53	2.09	3.00	6
12	1.76	3.24	5.11	1.80	2.71	5
13	1.63	2.76	3.26	1.61	1.00	6
14	2.05	3.07	4.16	1.06	1.59	3
15	2.02	3.42	4.79	1.23	1.12	NC
16	1.68	3.38	4.40	1.69	2.41	2
17	1.50	2.98	4.35	1.25	1.88	1
18	2.08	3.21	3.61	1.17	2.41	6
19	1.91	3.77	4.11	1.16	1.00	5
20	2.00	3.46	5.41	1.54	2.00	1
21	1.59	2.85	4.17	1.44	2.29	5
22	2.10	3.55	5.35	.91	2.00	2
23	1.71	3.51	4.03	1.98	2.65	5
24	1.68	2.69	4.05	1.46	1.88	2
25	2.08	3.75	4.38	1.35	.12	1
26	2.08	2.77	3.87	1.10	1.65	3
27	2.00	3.26	4.07	2.06	2.24	6

NC = not classified.

APPENDIX B

SUMMARY OF OBSERVED DATA FOR UNMOTIVATED GROUP

Subject	Sinus Arrhythmia				Heart Beat			
	Rest	1 Bit	2 Bit	3 Bit	Rest	1 Bit	2 Bit	3 Bit
1	261	197	154	205	58	62	58	60
2	274	142	108	174	69	78	74	78
3	322	190	218	226	91	97	92	94
4	393	243	217	156	91	95	97	93
5	308	155	389	207	68	73	82	75
6	271	163	119	147	92	94	94	92
7	460	329	335	226	90	81	74	72
8	354	317	218	153	78	85	85	94
9	137	158	169	153	74	80	76	78
10	457	223	219	239	72	78	77	74
11	338	185	122	81	76	87	89	94
12	470	201	214	171	85	98	96	102
13	230	97	109	85	61	58	62	60
14	216	192	174	124	70	80	74	73
15	260	95	143	154	80	84	82	79
16	258	107	107	114	84	89	82	83
17	476	421	274	285	76	88	84	85
18	299	317	243	340	99	111	114	116
19	128	110	125	147	64	66	72	76
20	134	137	112	135	82	82	79	82
21	282	165	159	265	76	86	87	82
22	175	116	222	113	81	83	83	86
23	321	149	64	113	92	95	108	102
24	34	32	27	20	110	111	110	111
25	185	69	73	88	88	88	88	87
26	191	307	174	191	83	89	89	82
27	213	127	153	100	77	84	88	83
28	323	170	202	151	113	109	119	111
29	377	243	162	105	101	112	120	120
30	231	122	117	103	92	102	102	97

Subject	Information Processing Rate			Scholastic QPR		SA Group
	1 Bit	2 Bit	3 Bit	Undergrad	NPS	
1	1.64	3.16	4.41	2.17	1.64	5
2	1.72	2.89	4.03	1.90	1.35	5
3	2.04	3.25	4.45	NA	2.00	1
4	1.79	3.44	4.38	1.27	2.59	4
5	1.78	3.18	4.18	1.66	2.06	6
6	1.70	3.84	4.06	1.36	2.12	2
7	1.97	3.90	4.37	1.53	2.35	3
8	1.32	3.02	3.60	1.26	1.35	4
9	1.73	3.04	3.55	1.41	1.88	NC
10	1.86	2.87	3.83	1.72	1.76	1
11	1.70	3.23	4.12	2.12	1.94	4
12	1.82	3.33	4.76	.95	1.65	3
13	1.42	2.49	3.01	2.00	2.12	3
14	2.05	3.24	4.12	2.66	3.00	4
15	1.65	3.00	4.20	2.36	2.88	6
16	1.82	3.22	4.29	1.46	-.53	1
17	1.93	3.31	3.84	1.59	1.82	2
18	1.76	3.08	4.14	1.32	2.76	NC
19	1.55	3.42	5.10	1.87	1.12	NC
20	1.38	3.54	4.99	2.01	1.88	NC
21	1.76	3.18	4.46	2.59	2.47	5
22	1.77	3.67	4.21	2.09	NA	6
23	1.90	2.84	3.87	2.03	1.24	5
24	1.69	2.85	4.34	2.61	2.53	NC
25	2.84	3.04	3.79	1.82	1.59	1
26	1.46	3.36	3.99	2.06	2.88	NC
27	1.17	2.26	3.71	NA	1.53	3
28	1.82	2.62	4.24	2.33	2.53	6
29	1.15	3.26	3.89	2.06	2.53	4
30	1.78	3.22	4.01	1.89	1.53	1

NC = not classified

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13. ABSTRACT

This experiment investigated the effect of motivation on sinus arrhythmia, heart beat, and information processing rate. The two way analyses of variance which were performed showed that motivation affected sinus arrhythmia and information processing rate and did not affect heart beat. A system was developed to classify the general patterns that resulted in the measure of sinus arrhythmia as information processing levels increased. This classification system may have eventual use in predicting a student's academic achievement.

14. KEY WORDS	LINK A		LINK B		LINK C	
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